Networks, Cables, and Connectors

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IMPACT OF THE COMPUTER IN EVERYDAY LIFE.
They are everywhere. From the ubiquitous beige box on our office desk to simple appliances we use everyday, the pervasiveness of computers in our lives is astounding. In a matter of a few decades, our world of information and communication has been transformed from paper (analog) to computers (digital). The way we use computers is also changing. Instead of having to go to a terminal or desktop system, we can now take our computers with us. Laptops, personal data assistants (PDA), and even digital phones allow us to accomplish many of the same tasks as their bigger, older, "immobile" siblings. And as fast as technology is moving, the way we will look at and interface with the computers of tomorrow will undoubtedly change.

THE WORLD WIDE WEB: JUST ANOTHER NETWORK
The most recent and biggest impact in computing and on society in general has been the World Wide Web. Anyone and everyone with a computer, from early adopters of computing technology to senior citizens purchasing their first computer, has benefited from the ability to communicate and transmit data anywhere in the world – twenty-four hours a day. The World Wide Web, in its simplest definition, is collection of networked computers. But it just happens to be the largest interconnected network in the world. But with all its capabilities, speed, and power a computer and computer networks cannot transfer and share data without transmission media – the network wiring or cables that carries the digital data.

SO, WHERE ARE WE GOING?
Here is a fundamental truth: A network is never any better than its cabling! You can add the finest servers and the most sophisticated application software, but if the cabling is poor, the network is poor. Cabling is fundamental! The purpose of this project is to provide a basic understanding of the importance of network cabling. In addition, the different types of cables currently in use, the capacities, type of connections, and the environments in which they are used will also be discussed. It will become apparent that the network cabling (media) of choice in new installations has narrowed to category 5 (Cat5) and fiber-optic cable. But the discussion of other cabling types is invaluable as existing networks and expanded networks still contain a large amount of older but still functioning cables.

When planning, designing, and implementing a network system, great care must be given to the selection and installation of the network cable. If you measure your network's downtime in dollars-per-second, your network cabling is a critical resource, calling for significant planning and care. Due to the long-term economic considerations, the selection and installation of a system of network cables is arguably one of the most important decisions to make during the design stage. Whether your project is an in-home peer-to-peer network or an enterprise network solution, a reliable, high quality network requires reliable, high quality network cable. It is important to understand the options and to carefully specify the needs.

ACKNOWLEDGEMENTS:
Under the first scratch of the surface the topic of network cables appears to be trite. After all, they are "just wires". But as you will quickly see, the subject of cables is more than just a minor importance – especially if the data you are transmitting is critical.

There are a number of technical manuals that go into great detail concerning networks and network cabling. But instead of being an “everything you need to know about network cabling” guide, the goal has been to keep this article succinct – but informative. Fortunately, nothing had to be invented or reinvented to create this article. The bulk of the research simply required the ability to *grok* the volume of repetitive information and interpret it for the reader (also note that no animals were used nor harmed during research). With that in mind I would like to acknowledge and direct the reader to the bibliography of sources at the end of this article.

Two books in particular, *How Networks Work* and *Practical Network Cabling,* written by Frank Derfler and Les Freed, were invaluable. The information delivered was very well organized, straightforward, and included a number of excellent illustrations – many of which were used in the conference display. I would like to thank Mr. Derfler for permission to use the illustrations from his books for this project, and would recommend his work to anyone desiring to learn more about the subject of networks and network cabling.

WHAT IS A NETWORK: A VERY, VERY BRIEF HISTORY

When the word network is used today, it usually refers to local area networks (LAN), the Internet, or cable TV. The forerunners of today’s networks were Western Unions Telegraph and the Bell Telephone systems.

In the 1860s, Western Union negotiated with the railroad industry for the right-of-way to expand their telegraph network. Paralleling the expanding railway system, telegraph lines and telegraph stations were common additions to rail depots. Western Union’s telegraph service was point-to-point. To send a telegram to someone, a person would go to the local Western Union office and dictate a message. The telegraph operator would send the message, by Morse code, to the appropriate station.

Without a single installed line, Bell Telephone started operations at the turn of the 20^{th} century. Like the telegraph system, telephone service was also point-to-point. The difference being Bell had to run new lines to the subscriber’s locations. Each phone could only connect to one other phone. As the popularity of phones increased, so did the demand for one phone to access multiple locations. The telephone network, its future of complex maze of lines, switches, cables, fiber-optic, and microwaves, was born.

Today’s computer networks are about sharing information. Networks are used to share everything from spreadsheet files, to printers, to email messages. The explosion of the Internet, and the World Wide Web, allows networked users half a world apart to communicate and collaborate as easy as using the telephone.

NETWORK VARIETIES

Computer networks are categorized based on a number of factors, including the type of devices, the number of devices, the connecting hardware used, and the distance between devices. In general, the three major types of networks are Local Area Networks (LAN), Wide Area Networks (WAN), and an internet.

Local Area Networks (LAN) consist of a number of computers physically located close to each other (usually the same area, room, or floor of a building) and are connected directly through special transmission lines. The physical layout, or LAN topology, can be a bus, star, or ring topology.

Wide Area Networks (WAN) consist of members that are located far from each other (on separate floors or different buildings). WAN members can be individual computer servers or a LAN group of computers. WAN’s are usually connected through public switched telephone networks and are established and operated by a national network administration authority specifically for transmission of data.

An internet is a network whose members are networks (LANs and WANs) themselves and are distributed over states, countries and continents. Devices called interworking units (IWU, also known as routers and gateways) are used to interconnect the networks. The largest internet is *the* Internet

GENERAL NETWORK COMPONENTS:
A computer network is a combination of hardware and software that allows computers and other peripherals to communicate with one another through some form of telecommunications media.

A computer network is made up of three major components:

Hardware: The equipment that connects to the network. Typically, this includes computers, printers, modems, etc. Each distinct piece of hardware on a network is known as a node.

Software: The programs that manage the transfer of data throughout the network, most commonly known as Network Operating Systems (NOS).

Transmission media: The cables or wireless signals that carry data from one node to another.

NETWORK OPERATING SYSTEMS AND PROTOCOLS
In a network, each member has its own operating system and the communications are managed through special software called Network Operating Systems. The network operating system (NOS) consists of a family of programs that run in networked computers. Some programs provide the ability to share files, printers, and other devices across the network. Computers that share their resources are called servers.

File servers store data files created by applications and often the application program itself. Other types of servers include print, fax, and Internet servers, which control specific tasks or data as required by the applications. Other programs that give the ability to use shared resources are called clients.

Client software works with the internal operating system of a computer so it can route requests from application programs and from the keyboard out to the various servers on the network. Client software relies on the redirector, which recognizes and routes service requests out of the PC and across the network.

Finally, the request from the client is packaged and sent across the network by the network communications software. This software, more commonly known as network protocols, specifies how a computer will format and transfer data. Protocols are agreements among different parts of the network community on how data are to be transferred. Protocols describe how things work. Committees established by organizations such as the Institute of Electrical and Electronics Engineers (IEEE), the Electronic Industries Association (EIA), and the International Standards Organization (ISO) typically labor for years to develop these agreements on how electronic devices signal, exchange data, and handle problems.

There are many standard sets of protocols in use, and it is possible for the same computer to use more than one protocol at the same time. Of the three standard protocols for network cabling and media access control used in the 1990s (ARCnet, ethernet, and token-ring), ethernet has evolved into the protocol of choice for a majority of network installations.

STRUCTURED CABLING SYSTEMS
Standards created by the EIA and the ISO are used to describe the building wiring system when designing and installing data and telecommunications networks. The goal of the standard is to describe a building wiring system that has a usable life of more than 10 years. There are six major parts to a structured cabling system: the work area, the horizontal cabling, the telecommunications closet (or wiring closet), backbone cabling, equipment room, and the entrance facility or the connection between a building and the outside world. The design of a structured cabling system should be independent of any specific vendor’s equipment.

TRANSMISSION MEDIA

A reliable, high quality network requires reliable, high quality network cable (media). While wireless networks are becoming more common, this work focuses on the wide variety of *physical* media used in networks today. Some networks consist of only one type of cable, such as Category 5 (Cat5), the most commonly used network cable, but the majority of networks use a combination of two or more cable types.

Keep in mind that while this document discusses a variety of network cables currently in use, the choice of physical media for new network installations has narrowed. The criteria for new network wiring include transmission speed, cost, and ease of installation. The media of choice is currently category 5 (Cat5) and fiber optic. While there is a growing demand for wireless technology, the subject is beyond the scope of this document.

MEDIA COMPONENTS:

In networks, the primary job of the connecting cable is to carry the signal from node to node with as little degradation as possible. The materials used to transmit data vary from media to media. At a minimum there is a path for the data or signal to travel, plastic insulation to cover the data path, and an outer cover (or jacket) for protection.

The data path for the majority of network cabling is copper (coaxial and twisted pair). Copper wire uses electrons to transmit the data signal. Two advantages of copper wire are low cost, and transmission speeds up to 100Mbps. The disadvantage to using copper is signal degradation as the electrical signal is under constant attack from the inside and out.

Electrical impulses from many sources such as lighting, electrical motors, and radio systems can attack the cable from outside. Additional materials such as foil or braided copper shielding are added to the network cable to protect the signal from external interference. Shielding is a brute force, but highly effective technique in providing a barrier to the interfering signals. Of course, the braid or foil covering increases the diameter of each cable and its cost.

Inside the cable, signals degrade because of various electrical characteristics, including resistance and reactance. Impedance is a complex electrical characteristic involving resistance and reactance. Each wire in the cable can act like an antenna, absorbing electrical signals from other wires in the cable. Electrical noise arising from signals on other wires in the cable is known as crosstalk.

Cancellation is a more elegant approach than shielding. Current flowing through a wire creates an electromagnetic field around the wire. Because the current flows in opposite directions within each wire in an active electrical circuit, the two fields rotate in opposite directions, cancel each other out, and also cancel outside sources of electrical noise. So, why the twist in the wire? In addition, twisting the two wires together strengths the fields’ capability to resist outside noise.

All copper network cables use one or both of these shielding and cancellation techniques to protect their data. On the bottom line, cables vary in their size, cost, and difficulty of installation primarily because of differences in the shielding and cancellation techniques they use.

Fiber-optic cable is made up of a collection of glass tubes spun as thin as hairs. Each tube can carry a single pulse of light that represents one bit in a data transmission. By bundling many of these fibers together, a single cable can transmit many bits at the same time.

A simple fiber-optic cable surrounds the glass fiber, cladding, and plastic coating with Kevlar – a semi-rigid material providing protection and strength. A protective outer jacket surrounds the Kevlar.

The two advantages to fiber are its immunity to internal and external electrical interference and speed. Since data is transmitted at *light speed*, fiber-optic provides the fastest transmission speeds. The down side to using fiber-optic cable is the high cost of materials and labor and it is inflexibility during installation.

Although fiber is alluring, it is difficult to justify the cost of running fiber to each desktop. Developments and standards have all moved to unshielded twisted-pair wire augmented by fiber-optic cable in special conditions. In modern installations, fiber makes up the backbone between wiring hubs and between buildings. Fiber also has an important role as the media of choice for gigabit ethernet.

TYPES OF MEDIA, CONNECTIONS, AND TOPOLOGIES:
The IEEE 802.3 committee designates each style of architecture according to signaling speed, type of signaling, and the maximum cable length (in meters) of one trunk segment. The following is a quick summary.

Cable Type	**Data Capacity**	**Length Before Amplification**	**Connection Type**
Fiber Optic	100Mbps-1Gbps	2,000 Meters	ST, SC, & SMA Fiber-optic Connector
Twisted Pair: Unshielded (UTP) Shielded (STP)	 10-100Mbps 10-100Mbps	 100 Meters 500 Meters	 RJ-45 IBM DataConnector
Coaxial Cable: Thinnet (10Base2) Thicknet (10Base5)	 10Mbps 10Mbps	 185 Meters 500 Meters	 BNC (British Navel Connector)

Fiber-Optic Cable:

Speed & Throughput: Fastest Possible
Average Cost Per Node: Most Expensive
Media & Connector Size: Tiny
Maximum Cable Length: Very Long

Description: The cable consists of a bundle of hollow plastic or glass fibers that carry independent streams of data. Pulses of light sent over the fibers transmit the data.
Compatibility: Long distance companies often use fiber optic cable to transmit data for telephone connections. ISP’s use fiber optics to send transmissions to and from the Internet.

Whereas copper wires carry electrons, fiber-optic cables made of glass fibers carry light. Because the signals it carries are pulses of light conducted over the threads of glass, fiber optic cables aren’t bothered by outside currents – a distinct advantage when there is a need for complete immunity form crosstalk and EMI/RFI. Because they are free of interference and the light pulses travel for miles without losing appreciable strength, fiber optic cables can carry data at high signaling speeds over long distances. Each glass strand only passes signals in one direction, so a cable has two strands in separate jackets. Under the jacket, a layer of Kevlar fibers (also used in bulletproof vests) provides cushioning and strength. Under the Kevlar, another layer of plastic, called the coating, typically adds cushioning and protection. Special connectors make an optical pure connection to the glass fiber and provide a window for laser transmitters and optical receivers. And since a two-fiber cable is about the same size as UTP, you can get many fiber cables in a single conduit.

So if fiber is so great, why use copper? The answer is that the combined cost of materials and labor of an installed fiber-optic LAN far exceeds the cost of UTP LAN. Although fiber is alluring, it is difficult to justify the cost of running fiber to each desktop. In modern installations, fiber makes up the backbone between wiring hubs and between buildings. Fiber also has an important role as the media of choice for gigabit ethernet.

Unshielded Twisted Pair (Ethernet or Category 5):

Speed & Throughput:	Fast Enough (10-100Mps)
Average Cost Per Node:	Least Expensive
Media & Connector Size:	Small
Maximum Cable Length:	Medium (500 meters)

Description: Ethernet cable usually consists of four pairs of twisted, copper wires. Before you can plug the cable into an NIC (Network Interface Card), you must connect a RJ-45 to the end of the cable.
Compatibility: You can use Ethernet cable to wire homes for telephone use. It also is commonly used for office network systems.

Unshielded twisted-pair cable (UTP) for networks combines four pairs of wires inside the same outer jacket. Each pair is twisted with a different number of twists per inch. There is no physical electrical shielding, either foil or braid, on UTP cable; it derives all its protection from the cancellation effect of the twisted-wire pairs. Network designers vary the number of twists in the different wire pairs within each cable. The mutual cancellation effect reduces coupling and crosstalk (electrical noise between adjacent pairs), and EMI/RFI noise produced in buildings such as motors, relays, and transformers.

Although unshielded twisted pair externally resembles common telephone wire, telephone wire lacks the twisting and other electrical characteristics needed to carry data.

Shielded Twisted Pair:

Speed & Throughput:	Fast
Average Cost Per Node:	Expensive
Media & Connector Size:	Large
Maximum Cable Length:	Medium (500 meters)

Description: This cable (called for only in the Token-Ring LAN specifications) uses a woven copper braid, a foil wrap between and around the wire pairs, and internal twisting of the pairs to provide a high degree of protection from outside electric currents. However, the combination creates a thick cable that rapidly fills the space in building wiring ducts.
Compatibility: The style of STP cable introduced by IBM for Token-ring uses a “belt and suspenders” approach to engineering. The shielded twisted-pair wire used in IBM’s Token-ring networking system shields each pair of wires individually to reduce crosstalk and then shields the entire cable to reduce outside interference. This conservative approach provides an excellent electrical environment, but the cable has a large outside diameter and is expensive.

Shielded twisted-pair (STP) combines both shielding and cancellation techniques. Not only is the entire cable shielded to reduce EMI/RFI, but also a separate shield to reduce crosstalk shields each pair of twisted wires from the others. In addition, each pair is twisted to benefit from the effects of cancellation. Note: unlike coaxial cable, the shielding on STP isn’t part of the signal path, but is grounded at both ends.

Coaxial Cable (10Base-2 or Electronic Telecommunications Cable):

Speed & Throughput: Fast
Average Cost Per Node: Inexpensive
Media & Connector Size: Medium
Maximum Cable Length: Medium (200-500 meters)

Description: This cable has an insulation-surrounded center wire. A layer of grounded, braided wire covers the insulation. When used with cable modems, a coaxial cable uses a BNC connector to attach to the modem. When traveling from the cable company to your home, a 1-inch coaxial cable is laid in trenches along with power cable and telephone cables. Once the cable reaches an amplifier, a .5-inch feeder coaxial cable travels from the amplifier to homes or offices.
Compatibility: You can find coaxial cable in older network architectures and in homes an businesses for delivering signals to cable televisions ad cable modems.

Although 10BASE-2 looks like the cable you use for your television, the electrical characteristics of the cable and the connector are different. This cable gets its name from the two conductors that share the same center axis; they are coaxial. Coaxial cable relies on woven copper braid to shield the center conductor from outside electric currents. The outer braid of coaxial cable makes up one half of the electrical circuit, in addition to acting as shielding for the inner conductor, so the braid must make a solid electrical connection at both ends of the cable. Poor shield connection is the biggest source of connection problems in a coaxial cable installation. BNC connectors placed on the end of the cable make contact with both the inner copper wire and the braided-copper mesh.

The Ethernet and ARCnet specifications both include coaxial cable, but they each call for a different type of cable. There is no provision for coaxial cable in token-ring.

The only new coaxial cable installations are in areas with very big EMI/RFI problems. But, despite its resistance to crosstalk and to EMI/RFI, the network industry has moved away from coaxial cable. Coax costs much more per foot than UTP and fills up conduit and wiring trays. And as the cost of fiber-optic cable decreases, network engineers are likely to choose it over copper coaxial cable when outside electrical interference is an obstacle.

THICK COAXIAL CABLE (10BASE-5)
The original DIX Ethernet standard was written for 10BASE-2 coaxial cable. The difference between BASE-2 and BASE-5 are segment length (500 meters for 10BASE-5 vs. 200 meters for 10BASE-2), flexibility (10BASE-5 is very rigid and difficult to work with), and appearance (10BASE-5 has a yellow outer jacket while 10BASE-2 is typically black). While 10BASE-5 *backbones* can be found, it is no longer being used in new networks.

THE INTERNET CONNECTION
One way that computers create temporary networks is through dial-up or telephony network connections to the Internet. Since the Internet is in essence a large network, the following is a brief discussion of transmission media used to make the connection.

T1 Line:

A T1 line is a dedicated telephone connection comprising 24-channels that can support a data transmission rate of 1.544Mbps. Each 64Kbps channel can be configured to carry voice or data traffic. These services are often used for high-capacity Internet connections.

ISDN (Integrated Services Digital Networking):

ISDN is an international standard for transmitting voice, video, image, and data to support a wide range of service over existing public telephone lines. Organizations and individuals requiring high-bandwidth transmission or the ability to provide simultaneous voice or data transmission over one physical line might choose this service.

Telephone Cable (Copper Twisted-pair Wire):

Phone cable originates from the phone company in large bundles of twisted-pair copper and fiber optic cable. The cable arrives at a neighborhood pedestal, and it travels to homes or businesses in bundles of two to six pairs of twisted-pair wire. In older homes, you will find only one or two pairs of wires, but in newer homes, where users require separate phone lines for business and modems, it is common to see six pairs of the twisted-pair wires. Phone cable is used to wire homes for voice and data communications.

PERIPHERAL ISSUES

The technical definition of a computer network is a collection of independent computers connected together to form a network to exchange and share data. Many of these networked computers have devices directly connected to them that are accessible to other computers when the devices host computer is logged into the network. These devices typically include printers, scanners, external modems, and external storage devices.

For completeness sake and with the emphasis on brief, the following is a *brief* discussion of the interface cables between a host computer and its devices.

Serial Cable:

In a serial bus, only one binary digit can be transmitted at a time. Therefore, a collection of binary digits would need to be transmitted sequentially, one after another. For example, transmitting one byte of data would require eight separate one-bit transmissions.

Parallel Cable:

A parallel cable transmits information simultaneously along a number of parallel paths. Therefore, transmission of a byte of data on an 8-bit bus would require only one transmission. The width of a parallel cables range from 8-, 16-, 32-, to 64-bit busses.

SCSI (Small Computer System Interface):

The SCSI interface defines a bus between units, as well as the protocols for data exchange among them. Each SCSI peripheral has its own controller and the controller is embedded on the device itself. Standard SCSI allows only seven devices per segment. Ultra SCSI allows up to fifteen devices per segment.

USB (Universal Serial Bus):

USB provides one hub port for connecting a large number of peripherals (up to 127) to the system bus, the cable (hub) snakes from one device to the next. All devices can function simultaneously. It supports plug and play controller cards that can be configured automatically at the time they are initially installed. All newer Intel chip sets support USB.

Fire Wire (IEE 1394 Standard):

FireWire is a serial bus type whose standard is proposed by IEEE 1394. It is a universal 6-wire connector designed to replace serial, parallel, SCSI and other types of ports. It can only support a maximum of 63 devices. It is designed to support speeds of 100Mbps, 200Mbps, and 400Mbps.

FireWire cable consists of six wires. Data is sent on two pairs of twisted-pair wire, and two wires carry the power. FireWire is for digital data transmissions between camcorders or cameras and a PC. Eventually, FireWire will be used to network.

LAN ADAPTERS

The cabling connects to LAN adapters in the various network nodes. Some LAN adapters, also called network interface cards (NICs), are separated printed-circuit boards designed for computers that range in size from desktop PCs, to IBM AS/400 midframe machines, to communications controllers from IBM mainframe computers. Some companies manufacture products with integrated LAN adapters – built into the components of computers.

Each LAN adapter has three important jobs:

§ Make a physical connection
§ Provide electrical signal
§ Implement orderly access to the shared network cable system

Proper installation of connectors is crucial. Improper installation of the connector on the cable is the most common source of poor cable connections. Poorly installed connectors can create electrical noise, make intermittent electrical contact, and disrupt the network. It pays to invest in the best connectors and installation tools.

Definitions & Terminology:

ARCnet (Attached Resource Computer Network) An inexpensive and flexible network architecture created by Datapoint Corporation in 1977,which uses the token-passing channel access method.

ARCnet Plus The successor to ARCnet, which supports transmission up to 20Mbps.

Attenuation The decrease in power of a signal as it travels along the cable. Attenuation is undesirable because it reduces the changes in voltage that signal a one or a zero in the digital signaling stream.

Category (1-5) Cable The Electronic/Telecommunications Industries Associations designations for unshielded twisted-pair cable are described in terms of categories, labeled Category 1, Category 2, etc; often, these are abbreviated as Cat1, Cat2, etc.

Coaxial Cable A type of cable that uses a center conductor, wrapped by an insulating layer, surrounded by a braided wire mesh and an outer jacket or sheath, to carry high-bandwidth signals such as traffic or broadcast television frequencies.

Crosstalk The spillover of a signal from one channel to another. In data communications it is very disruptive. In cable systems, crosstalk comes from adjacent cable pairs.

EMI/RFI (Electromagnetic Interference) outside sources of potential interference on your network cable. EMI/RFI sources include radio transmitters, electric relays and switches, thermostats, fluorescent lights.

Ethernet A networking technology developed in the early 1970's, Ethernet is governed by the IEEE 802.3 specification and remains one of the most popular types of networking technology in use today.

Ethernet II Ethernet frame type used by TCP/IP.

FDDI (Fiber Distributed Data Interface) A network architecture that uses fiber-optic cable and two counter-rotating rings to reliably send data at 100Mbps.

Fiber-Optic A cabling technology that uses pulses of light sent along a light-conducting fiber at the heart of the cable to transfer information from sender to receiver. Note: Fiber-optic cable can send data in only one direction, so two cables are required to permit any two network devices to exchange data in both directions.

Impedance a complex opposition to the flow of an alternating current in a circuit. Elements of distributed inductance, distributed capacitance, and resistance combine to create impedance.

IPX/SPX (Internetwork/Sequenced Packet eXchange) The set of protocols developed by Novell that is most commonly associated with NetWare but is also supported by a number of other vendors as well.

ISDN (Integrated Services Digital Network) International standard for transmitting voice, video, image, and data over the public telephone lines.

NetBEUI (NetBIOS Enhanced User Interface) An enhanced set of network and transport protocols built in the late 1980's to carry NetBIOS information, when earlier implementations became to limiting for continued use.

NetBIOS (Networked Basic Input/Output) A venerable set of application programming interfaces designed by IBM in the late 1970's to provide easy access to networking services. It is still a popular networking interface.

NIC (Network Interface Card) A PC adapter board designed to permit a computer to be attached to some sort of network medium, the NIC handles the translation of digital information into electrical signals for outgoing network communications and translates incoming signals into their digital equivalent for delivery to the machine where it's installed.

Reactance An electrical characteristic where opposition to the changes in voltage and current causes signal degradation.

Resistance An electrical characteristic where opposition to the flow of electrons causes signal degradation.

RFI (Radio Frequency Interference) *See EMI (Electromagnetic Interference)*

SPX/IPX *See IPX/SPX*

T1 Line A dedicated telephone connection comprising 24-channels that can support a data transmission rate of 1.544Mbps.

TCP (Transmission Control Protocol) The core of the TCP/IP suite; TCP is a connection-oriented protocol responsible for reformatting data into packets and reliably delivering those packets.

TCP/IP (Transmission Control Protocol/Internet Protocol) Represents the set of protocols used on the Internet.

Token Ring A network architecture developed by IBM, which is physically wired as a star but uses token-passing in a logical ring topology.

Token-passing A channel access method used mostly in ring topology networks, which ensures equal access to all computers on a network through the use of a special packet called the token.

Topology Term used to describe the basic physical layout of the network.

TP (twisted pair) A type of cabling in which two copper wires, each enclosed in some kind of sheath, are wrapped around each other. The twisting permits narrow-gage wire – otherwise extraordinarily sensitive to crosstalk and interference – to carry higher-bandwidth signals over longer distances than would ordinarily be possible with straight wires. TP cabling is used for voice telephone circuits as well as for networking.

UTP (unshielded twisted-pair) A form of TP cable that includes no additional shielding material in the cable composition, UTP cable encloses one or more pairs of twisted wires inside an outer jacket.

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